Improving the Interface between Industry and Army Science and Technology

Some Thoughts on the Army's Independent Research and Development Program

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Introduction

The Army science and technology (S&T) program is conducted both in-house and in external laboratories. The program consists of basic research, applied research, and advanced development, known by their respective budget codes of 6.1, 6.2, and 6.3. The 6.1 basic research program is conducted primarily through grants to academia, although some research is conducted in-house. There are also some 6.1 efforts, such as the Army's collaborative technology alliances (CTAs), that bring together subject matter experts from industry and academia with counterparts from the DOD laboratories. The 6.2 applied research program also consists of in-house and external efforts. Here, the external efforts involve more industry technologists than are seen in the 6.1 program. The 6.3 program, because of its developmental nature, is primarily executed by industry, but is overseen by in-house technologists.

All of the interfaces between the in-house laboratories, academia, and industry serve to broaden and strengthen the Army S&T program. DOD sponsorship of the Independent Research and Development (IR&D) program in industry has the same goals. This paper presents the various ways that the Army laboratories link their work with external laboratories and looks for ways to improve these interfaces, with special emphasis on the IR&D program. The paper begins with a review of some successful interfaces between in-house efforts and those in the private sector. Examples of important interfaces leading to successful development of Army systems are taken from earlier studies.[1] In these references, the close working relationships between Army laboratories, especially the Research, Engineering, and Development Centers, and the contractors that were building the particular systems under review are shown. We then provide important background on the IR&D program, including a discussion of efforts by the other Services to improve their IR&D interface. We also review Service participation in the IR&D program and provide commentary from interviews with selected individuals who have had experience with the IR&D program. These include personnel from the Army, the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (AT&L), other DOD components, and the private sector. The paper concludes with a review of these comments and offers conclusions and recommendations for improving the Army's ability to ally itself more closely with the IR&D program.

[1] R. Chait, J. Lyons and D. Long, "Critical Technology Events in the Development of the Abrams Tank," *Defense & Technology Paper 22* (Washington, DC: Center for Technology and National Security Policy, 2005); R. Chait, J. Lyons, and D. Long, "Critical Technology Events in the Development of the Apache Helicopter," *Defense & Technology Paper 26* (Washington, DC: Center for Technology and National Security Policy, 2006); J. Lyons, D. Long, and R. Chait, "Critical Technology Events in the Development of the Stinger and Javelin Missile Systems," *Defense & Technology Paper 33* (Washington, DC: Center for Technology and National Security Policy, 2006); J. Lyons, R. Chait, and D. Long, "Critical Technology Events in the Development of Selected Army Weapons Systems," *Defense & Technology Paper 35* (Washington, DC: Center for Technology and National Security Policy, 2006); R. Chait, J. Lyons, D. Long, and A. Sciarretta, *Enhancing Army S&T: Lessons from Project Hindsight Revisited* (Washington, DC: Center for Technology and National Security Policy, 2007).

External Interfaces in Army S&T–Some Examples

To illustrate the interactions of DOD technical staff with external R&D we use a number of S&T programs, with a focus on Army S&T programs as examples. The scientists and engineers conducting these programs are not only part of Army technical organizations, but are also members of the worldwide technical community. The examples used are the Army Research Laboratory's collaborative technology alliances, the Army's University Affiliated Research Centers, the Army Research Office's individual investigator grants program, the National Automotive Center, the Small Business Innovative Research program, the Small Business Technology Transfer program, the National Rotorcraft Center, and cooperative research and development agreements.

The Army Research Laboratory's Collaborative Technology Alliances
The Army Research Laboratory (ARL) manages several formal efforts in collaboration in which Army technical work and complementary work by outside consortia are jointly managed. Each CTA is jointly planned, managed, and executed as a single program, without distinction as to where the work is being done. In this arrangement, the interface with the external participants is strong. The CTAs were established in the 1990s in response to a major initiative by the Army Chief of Staff to "digitize the battlefield." [2,3] This required ARL to provide basic and applied technologies in areas in which it had not previously specialized. To move rapidly, it was necessary to enlist expertise in academia and industry, and to do so in a manner that allowed ARL to develop matching expertise over the duration of the CTA agreements. In this way, ARL would build up its capabilities in basic and applied research on advanced systems of communications, computing, and associated technologies. It was apparent that these technical areas would be of increasing importance in the years ahead.

The CTAs consist of consortia, each of which is led by an industrial member with experience in researching, producing, and fielding digital systems. Each consortium has members from industry and universities, including minority institutions, such as Historically Black Colleges and Universities. Bidders agree to reach internal agreement on their intellectual property arrangements. They also agree to rotate some of their technical staff to ARL and, in turn, accept staff rotating from ARL. The rotation is designed to maintain open communication channels and enhance technology transfer. The contract vehicle is a "cooperative agreement" (not to be confused with a CRDA or cooperative research and development agreement). The cooperative agreement format allows the Army to manage the contracted work as though it is being done in-house. In contrast, if the Army uses an ordinary contract or a grant mechanism, the work is directed by the awardee and is essentially performed at arm's length from the sponsor.

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[2] J. Lyons, "Army R&D Collaboration and the Role of Globalization in Research," *Defense & Technology Paper 51* (Washington, DC: Center for Technology and National Security Policy, 2008).
[3] Army Research Laboratory, *Collaborative Technology Alliance: Technology for the Soldier*, available at <www.arl.army.mil/www/DownloadedInternetPages/CurrentPages/CTA/Documents/reports/ARL-CTA_Book_07-08.pdf>.

The upshot of the CTA arrangement is to extend ARL's competence beyond its in-house capabilities by drawing on the expertise in its partners' laboratories and having ready access to their equipment and facilities. This creates useful leverage. It is true that one obtains leverage in any contract, but CTAs differ in important respects. First, the relationships are several years in duration. Second, they are relatively large for basic and applied research—on the order of five million dollars per year for 5 years. Third, the relationships lead to unusually close and cooperative work, made possible by the cooperative agreement authority, as discussed in the previous paragraph.

As ARL moved forward with the CTAs—initially numbering three, now expanded to five, including one international arrangement (see table 1)—other Army laboratories began to participate. The CTAs hold annual symposia, attended by technologists across the Army, in which the progress made in each consortium is presented. Representatives from other Army laboratories also participate in the planning meetings for each CTA.

Table 1
Past, Current, and Planned CTAs[4]

Completed
Power and Energy Advanced Sensors
Current
Micro Autonomous Systems Robotics Communications and Networks Advanced Decision Architectures Networks and Information Science*
Planned
Network Sciences New Robotics Cognition and Neuroergonomics

***** The International Technology Alliance between ARL and the UK Ministry of Defense is modeled on a CTA.[5]

These new, formal collaborations have extended the range and scope of ARL. They have made good use of the skills and resources of research groups in the private sector, both academic and industrial. It is difficult to quantify the results thus obtained, but they are

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[4] For more information see the Army Research Laboratory website, available at <http://www.arl. army.mil/www/ default. cfm?Action=93>.

[5] J. Lyons, "Army R&D Collaboration and the Role of Globalization in Research," *Defense & Technology Paper 51* (Washington, DC: Center for Technology and National Security Policy, 2008); also see the Army Research Laboratory website, available at <http://www.arl.army.mil/www/default.cfm? Action=30&Page=77>.

substantial. Clearly, the Army and the Congress believe in the efficacy of this model, given their continuing authorization and appropriation requests for support of the existing collaborations and the apparent good prospects for additional ones.

University Affiliated Research Centers

The Army Research Office currently funds a number of University Affiliated Research Centers (UARCs), which are stand-alone centers of excellence comparable to CTAs. Both are consortia, consisting of the entity and one or more partners. UARCs are focused in one university or led by a university, in contrast to the industry-led CTAs. The operation is more or less self-managed, in contrast to the very close relations between CTAs and ARL. Both approaches create large centers of excellence over several years, with the possibility of renewal. They represent substantial extensions of the scope of the Army S&T program.

The first UARC reviewed here is the Institute for Soldier Nanotechnologies (ISN) at the Massachusetts Institute of Technology (MIT). The ISN is a set of research programs on ways to use the unusual characteristics of nano-size particulates to fulfill Army needs. The ISN is "an interdepartmental research center founded in 2002 by a $50 million, five-year contract with the U.S. Army Research Office … now in its second five-year contract."[6] The ISN has three industrial partners as well as informal partnerships within the DOD laboratories.

A second UARC, the Institute for Collaborative Biotechnologies (ICB) at the University of California at Santa Barbara, is also funded at about $50 million over 5 years. It works in real-time collaboration with its partner universities, the California Institute of Technology and MIT, as well as participating groups from industry, Army laboratories, and other research centers. Approximately 60 academic researchers are involved in the work.[7] There are no staff rotations built into the UARC contracts.

The Army Research Office's Single Investigator Research Grants

The primary function of the Army Research Office (ARO) is to manage a large and varied program of grants, primarily to individual investigators in universities, to carry out basic studies in areas of interest to the Army. Basic research proposals from educational institutions, nonprofit organizations, and private industry are competitively selected and funded. ARO's research mission represents the most long-range focus of the Army's efforts to exploit emerging technologies.

The advantage obtained from the interface with ARO's grantees is clear. Every grant enlarges the coverage of the Army S&T program, enlists the intellects of top scientists and engineers, and often brings into play special research equipment not available at

[6] For more information see the MIT Institute for Soldier Nanotechnologies website, <http://web.mit.edu/isn/partners/index.html>.

[7] Reed Skaggs, "Exploiting Technical Opportunities to Capture Advanced Capabilities for Our Soldiers," *Army AL&T Magazine* (Oct-Dec 2007), available at <http://asc.army.mil/docs/pubs/alt/2007/4_OctNovDec/articles/16_Exploiting_Technical_Opportunities_to_Capture_Advanced_Capabilities_for_Our_Soldiers_200710.pdf>. For more information see the Institute for Collaborative Biotechnologies website, <http://www.icb.ucsb.edu/research>.

Army laboratories. Army technical personnel participate in reviewing research proposals and often sit in on progress reviews. In this way, Army S&T staff increase their knowledge of research at the frontier of basic science.

A challenge for Army in-house laboratories is how to enhance contacts between laboratory research staff and the ARO grantees. While Army researchers who are already actively engaged certainly benefit, many researchers are not engaged. ARO management is conducting "road shows" on which senior program managers and ARO leadership visit Army laboratories to increase awareness of the grant activities. The Army Science Conferences (ASC) and other venues provide additional opportunities for contact at the bench level. However, the ASC only meets every other year. It would be useful to find a way to make such contacts more frequent.

The ARO, as is the case for many of the Army laboratories, is not well appreciated by senior Army leaders, who see finished systems that are almost always manufactured by industry. The roles of ARO and Army laboratories in these successes are hidden—there are no nameplates with names of contributing Army technical programs. It is often the case that the research that enabled successful fielding of new systems was performed many years earlier, during the terms of officers who have long since moved on to other assignments. One way to bring the ARO to the forefront in the thinking of Army leaders is to reinstitute the regular meetings of the ARL Army Stakeholders Advisory Board. In the 1990s, this group received briefings from the ARL research directorates and engaged with laboratory management in discussions of issues affecting the performance of the laboratory (ARO was not then a part of ARL). At the time, the Board consisted of three-star deputy chiefs of staff of the Army for various functional areas and was chaired by the four-star Commanding General of the Army Materiel Command. If meetings of this kind could be reestablished, both ARO and the ARL as a whole would benefit. The assumption is that the more Army leaders who know about the Army's research programs, the more those programs would receive the leaders' understanding and support.

The Small Business Innovative Research Program

The Small Business Innovative Research (SBIR) program was established by Congress in 1982 in recognition of the contributions to the economy by small entrepreneurial firms.[8] The goals of this program are to stimulate technological innovation, use small business to meet Federal research and development needs, foster and encourage participation of minorities and disadvantaged persons in technological innovation, and increase private sector commercialization derived from Federal research and development. Typically, firms have no more than 500 employees.[9] The funds are derived by a 2.5 percent tax on the S&T extramural programs at Federal agencies. Only those agencies with at least $100

[8] For a full and comprehensive review of the SBIR program, see Charles W. Wessner, ed., *An Assessment of the Small Business Innovation Research Program*, Committee on Capitalizing on Science, Technology, and Innovation (Washington, DC: National Research Council, 2008), available for download at <http://www.nap.edu/catalog.php?record_id=11989>.

[9] U. S. Small Business Administration, "Table of Small Business Size Standards Matched to North American Industry Classification System Codes," August 22, 2008, available at <http://www.sba.gov/idc /groups/public/documents/sba_homepage/serv_sstd_tablepdf.pdf>.

million in extramural work are taxed. Eleven agencies meet this criterion, one of which is DOD. DOD contributes $943 million, about half of the Government total. The details at the eleven agencies vary, but all conduct a three-phase program. Phase I is an award of about $100,000 to do preliminary planning and study. Phase II awards between $0.5 million and $1 million to carry the effort to a prototype product or process. The third phase is commercialization and is supported by non-SBIR funds.

Although the SBIR program was initially viewed by the agencies as a drag on their programs, experience has shown that great contributions have been made by participants from small business. Attitudes have changed in response to the program's successes. The relationships between the in-house sponsor and the small business participants have become closer. During briefings at the laboratories it is sometimes difficult to tell which parts have been done by in-house staff and which have been done by SBIR participants, because of the integration of the SBIR work. In many cases the SBIR contributions have been critical for the overall program's success. Examples of program successes have been described by a program manager.[10]

In 1994, the Small Business Technology Transfer (STTR) program was established as a follow on to the SBIR program. The STTR, provides up to $850,000 in early-stage R&D funding directly to small companies. Under the STTR program, small businesses must have partners in universities, federally funded research and development centers, or other nonprofit research groups.

The National Automotive Center[11]

The National Automotive Center (NAC) was established at the Tank Automotive Research and Development Center (TARDEC) in 1993 to develop dual-use automotive technologies for use in military ground vehicles. It seeks to accomplish this task by fostering collaboration with industry and academia in basic research, applied research, and advanced development. Mechanisms used by the NAC for cooperating with the private sector via contracts include. SBIR contracts, cooperative research and development agreements (CRADAs), and cooperative agreements. Funding comes from TARDEC's 6.1 and 6.2 funding, and from private sector participants. A program featured in the article in ref. 11 is hybrid vehicle development, including energy storage (batteries) and energy and power management.

The National Rotorcraft Technology Center

The National Rotorcraft Technology Center **(**NRTC) is an arrangement unusual in its use of industry IR&D funds. The NTRC budget is about $10 million per year, half from Government, half from industry (and assigned to IR&D accounts). The Army is the principal Government member; the Navy and the Federal Aviation Administration (FAA) also participate. The NRTC serves as a forum for the rotorcraft industry. NRTC's Center for Rotorcraft Innovation (CRI) is a consortium of a half-dozen industry members and an

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[10] "The Army SBIR Program," briefing by Christopher S. Rinaldi, Fort Detrick, MD, May 5, 2009. Charts provided to authors by email May 22, 2009.

[11] For more information, see the U.S. Army Tank Automotive Research Development, and Engineering Center website, available at <http://tardec.army.mil/nac.asp>.

additional group of associate members from eight universities. Interest on the Army side is from aviation Research, Development and Engineering Centers (RDECs) at Huntsville, AL, and Fort Eustis, VA, and the Army Research Laboratory Vehicle Technology Directorate at both NASA Langley and NASA Glenn. Army scientists and engineers in the aviation area take advantage of the NTRC to interact regularly with industry. They also review proposals to the NRTC/CRI program.

The NRTC manages 6.2 funds (from Army, Navy, and FAA) of approximately $5 million per year, plus matching CRI funds from the rotorcraft companies; together these go to fund the roughly $10 million NRTC/CRI 6.2 program. There is also a 6.1 Center of Excellence Program investigating basic research on topics related to rotorcraft technology. This is a separate program funded at about $2 million per year, split about evenly between Georgia Tech and Penn State. In sum, NRTC is effectively promoting information sharing between Government and industry partners. Industry is using IR&D funds for NRTC projects.

The IR&D Program

According to a RAND Corporation study, the IR&D program has its roots in the Vinson-Trammel Act of 1934, which aimed at limiting contractor profits.[12] The program has undergone several changes in emphasis and requirements since then. The definition of IR&D is as follows:

> IR&D is research and development initiated and conducted by contractors; it is not specified under any contract or grant. It is funded and managed at the contractor's discretion from contractor-controlled resources, with a portion of the costs later recovered in the overhead portion of DOD contracts.[13]

The definition ultimately required DOD to define what costs would be acceptable and thus eligible for reimbursement. Over the years the program particulars have varied from requiring the research to be directly related to specific programs to the current requirement that the work *not* be related. The RAND Corporation presents the goals of the program as:

1. Encouraging greater contributions to technology related to future defense systems.
2. Hedging against the uncertainties, inflexibilities, and short time horizons of defense planning and systems development.
3. Promoting the movement of new ideas and technologies into enhanced defense capabilities.[14]

By the 1980s, the process requirements had developed into a burden on both the contractors reporting their research and the military evaluators required to determine the validity of their claims. In 1983, there were some 30,000 evaluations done on 10,000 projects. Each of these consisted of a one-page summary and a brochure of up to 30 pages. This evaluation load was reduced by Public Law 102-190, the National Defense Authorization Act for 1992–1993. The act also removed certain dollar limits on IR&D spending. The language eased the restrictions on contractors as to what work could be counted. In particular, it stated that "… the Department of Defense shall not infringe on the independence of contractors to choose which technologies to pursue in their IR&D activities."[15]

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[12] A.J. Alexander, P.T. Hill, and S.J. Bodilly, *The Defense Department's Support of Industry's Independent Research and Development (IR&D): Analyses and Evaluation* (Santa Monica, CA: The RAND Corporation 2007), 3.
[13] Ibid.
[14] Ibid., 17.
[15] National Defense Authorization Act for Fiscal Years 1992 and 1993, Public Law 102-190, 102nd Congress, Section 802.

Managing the Current IR&D Program

The latest statement on the IR&D program, dated January 2007, is as follows:

> The regulations under subsection (a) shall encourage contractors to engage in research and development activities of potential interest to the Department of Defense, including activities intended to accomplish any of the following:
>
> (1) Enabling superior performance of future United States weapon systems and components.
> (2) Reducing acquisition costs and life-cycle costs of military systems.
> (3) Strengthening the defense industrial base and the technology base of the United States.
> (4) Enhancing the industrial competitiveness of the United States.
> (5) Promoting the development of technologies identified as critical under section 2506 of this title.
> (6) Increasing the development and promotion of efficient and effective applications of dual-use technologies.
> (7) Providing efficient and effective technologies for achieving such environmental benefits as improved environmental data gathering, environmental cleanup and restoration, pollution reduction in manufacturing, environmental conservation, and environmentally safe management of facilities.[16,17]

After the requirements were changed in 1992, DOD set up policies, procedures, and a management structure for the coordination of technical information exchanges relevant to IR&D between industry and military technologists. This was to be managed by the Director of Defense Research and Engineering (see appendix B).

The IR&D program is one of the larger efforts in DOD research and development. Figure 1 on the next page shows the history of amounts spent by contractors for all Federal agencies and the amounts allocated to DOD.[18] The lightly shaded area represents all U.S. Government agencies in the IR&D program. The darker area represents DOD contractors.

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[16] Item (g), "Encouragement of Certain Contractor Activities," in US Code Title 10, Subtitle A, Part IV, Chapter 139, Section 2372.

[17] For more information see the DOD IR&D website at <http://www.dtic.mil/ird/stats/index.html#spending>.

[18] Ibid.

Figure 1
IR&D Costs for Fiscal Years 1977–2000.

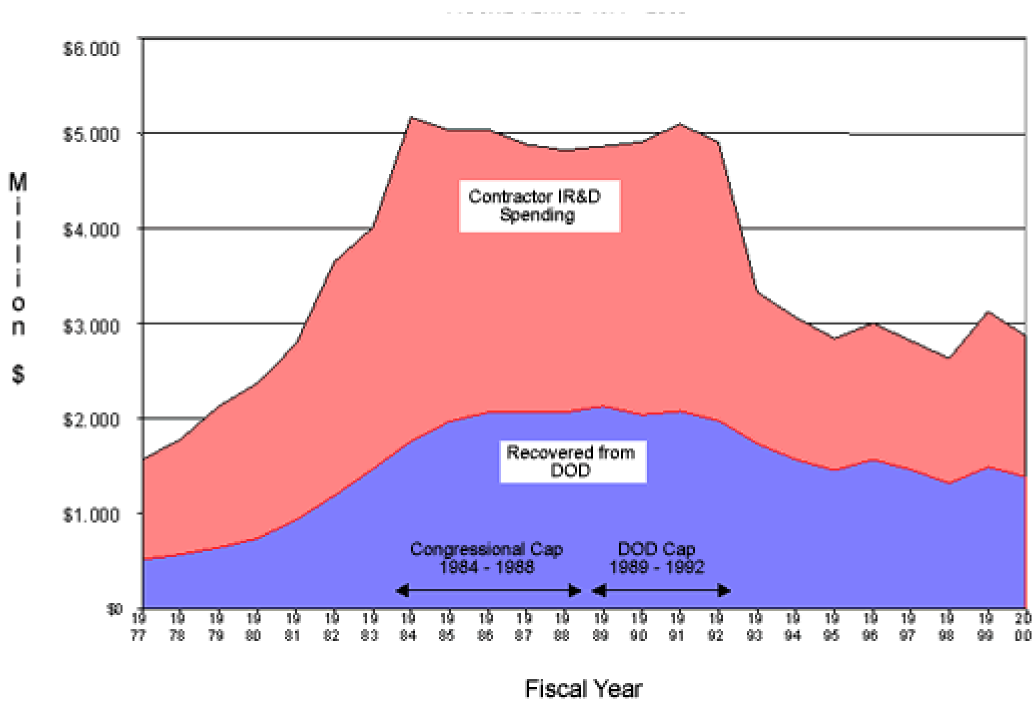

Table 2 gives data for just the DOD portion of IR&D over 2 years. Note that the amounts are considerably greater than in the year 2000, the last year in figure 1.

Table 2.
Summary of DOD IR&D Costs and Major Defense Contractor Sales[19]

	2006	2007
IR & D incurred costs	2.377*	2.436
Sales, total to DOD	167.416	176.421
Percent of claimed IRD costs reimbursed	95.1%	95.2%

***** Dollars in billions

[19] Office of Cost, Pricing, and Finance, Office of Defense Procurement and Acquisition Policy, “Summary of DOD Independent Research and Development and Bid and Proposal Costs Incurred And Sales Achieved By Major Defense Contractors,” available at <http://www.acq.osd.mil/dpap/policy/cpf/fy06-07.pdf>.

However, over the ensuing years efforts to manage the DOD interface with industry on IR&D have come to very little. There is now no full-time OSD employee responsible for oversight of the IR&D program. Recently, an ad hoc working group was set up in the Office of the Under Secretary of Defense for AT&L to revisit DOD management of the program. A database on IR&D projects that contains information supplied voluntarily by DOD contractors is managed by the Defense Technical Information Center (DTIC), and can be accessed only by registered DOD employees.[20]

The DTIC IR&D database consists of both the IR&D reports and a web-based retrieval engine, which also provides summaries of the reports. The reports begin with introductory data, including various identifiers, report and project dates, and contact information for a company representative. This section also contains project cost estimates, including data for the current and prior year. Several codes are provided to classify the project by subject area, keyword, and sensitivity. The second section of the reports contains a series of open-ended descriptions of project details, under the headings Need, Objective, Approach, and Progress. DTIC informs us that the total dollar value of all submitted reports in 2006 was roughly $1.3 billion dollars, which represents about half of DOD IR&D costs.[21]

For appendix C, we isolated the project reports of five randomly selected large defense contractors and reviewed up to 100 of their IR&D submissions from 2006. Our first stage of review was an attempt to assess the total cost of IR&D projects submitted by these five companies; we found this to be about $266,000,000 in 2006. This includes two contractors submitting more than 50 but fewer than 100 reports, one contractor submitting fewer than 20 reports, and a fourth who submitted more than 300 reports. In the last case, we reviewed only 100 of these reports and extrapolated to get an estimate of their total value, which was included in our final figure.

For our second phase, we reviewed 40 reports from the first sample in detail in order to evaluate the quality of the technical disclosure therein. We found that about half of the reports failed to describe the methods and results of their research in sufficient detail to significantly assist planning DOD R&D efforts building on their work. About a quarter of the reports failed to provide any description at all, and a substantial subset of these did not appear to be appropriate topics for IR&D reimbursement, such as management projects and projects that do not appear to be research. Our overall conclusion is that the database is serving to provide more information than would be available in its absence, but the total dataset is far from a complete picture of the research being reimbursed by DOD. Further, less information is available than was expected by the database's creators. The reason for the incompleteness is that providing this technical information to DOD is voluntary.

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[20] Information on registration is available at <http://www.dtic.mil/ird/dticdb/index.html>.
[21] Email from Mr. David Hyman, DTIC, February 3, 2009.

Air Force, Navy, and Army IR&D Programs

In light of the size of the IR&D program, it is not surprising that there are local DOD efforts underway to improve the interaction between industry and the DOD laboratories. In addition to the study by the ad hoc working group at OSD, the Air Force has established a formal structure that operates across the Air Force Research Laboratory (AFRL) and the Air Force product centers to arrange and manage IR&D interactions with contractors.[22]

The Air Force Program

The Air Force effort is based on the principle of quid pro quo. AFRL and the Air Force product centers provide information to industry, and industry responds by describing its forward looking research in the IR&D program. AFRL‘s IR&D briefing process has three distinct steps:

1. The Air Force communicates its needs to industry by way of the Air Force product centers. AFRL subject matter experts brief AFRL research programs to industry.
2. Industry responds by passing information to the Air Force on their IR&D research.
3. Both parties adjust and synchronize their respective programs.

These briefings are carried out for individual companies. According to the AFRL project manager, the defense industry has been willing to share IR&D information and accept feedback from DOD. However, industry typically resists DOD dictation of the content of IR&D work. Industry representatives have generally preferred to have face-to-face discussions on their research, rather than relaying information through the DTIC database.

The Navy Program

The Navy has no policy or official program regarding IR&D. However, it does have active programs with industry that fulfill many of the objectives that might apply to an IR&D effort.[23] The Navy's Office of Naval Research (ONR) conducts S&T industry partnership conferences. These provide the Navy with opportunities to communicate with industry—opportunities that are similar to those once available through IR&D reviews. The annual partnership conferences set forth 13 Navy focus areas for industry during 3 days of overviews. Each year, the Navy reviews four or five areas in depth, so that all areas are covered in 3 years.

[22] Information supplied by Mr. Giovanni Pagan of the AFRL's Plans and Programs Directorate, October 17, 2008.
[23] Information from telephone conversation with Joe Lawrence of the Office of Naval Research, April 1, 2009.

These conferences provide opportunities mainly for the Navy to speak to industry. Industry information is provided privately to the Navy by individual companies, if they so chose, during the conferences. They focus on a particular topic to discuss their S&T work (presumably this is IR&D related). In addition, the Navy has a very large 6.2-6.3 program which funds S&T work that addresses future Navy capability needs (FNCs). The funds for the FNC program are largely intended to go out to industry on contract. This program can be a vehicle for stimulating industry to provide information on their independent research. The reasoning is that if the Navy knows that a company has something new in its independent research work, then that might stimulate the FNC program to add funding to the area, providing that company with an opportunity to compete strongly for IR&D contracts.

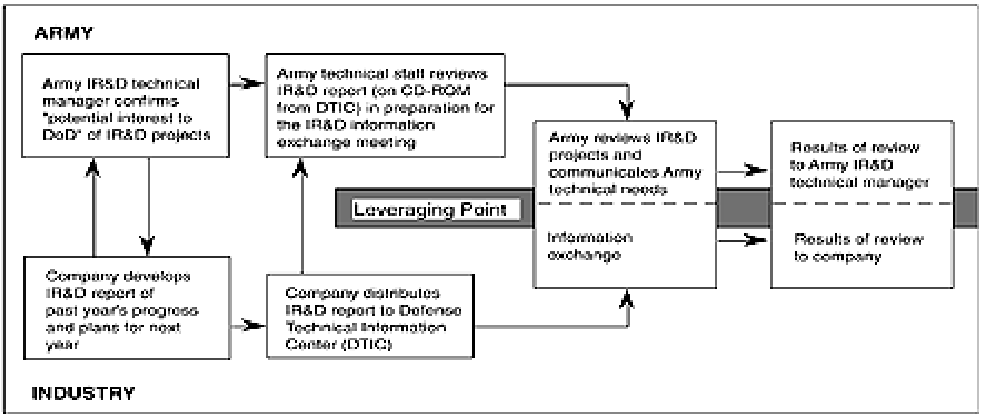
ONR does not use the DTIC IR&D database. However, personnel suggest that they would if it were complete. One idea that would facilitate this capability would be for the Navy to require evidence from the DTIC database that a company is working in a given research area before consenting to sign a contract with the company concerning that area.

The Navy partnership program is similar to the Air Force program, albeit less formal. The Navy holds one large meeting for the whole of defense industry, whereas the Air Force meets separately with individual contractors. The Air Force requires two-way communication, holding separate meetings for the Air Force's discussion of its S&T programs and future needs, and for the contractor's discussion of its IR&D program. The Navy allows companies attending the partnership conferences to decide whether to share their IR&D work.

The Army Program

In its 1997 publication of the Army Science and Technology Master Plan, the Army described its IR&D efforts as shown in figure 2. The process was logical and should have been effective. However, the Army's interaction with the IR&D program is currently incomplete. Discussions with the Research, Development, and Engineering Command's laboratories (under the Army Materiel Command) have shown that organized procedures to ensure awareness of industry's IR&D efforts vary greatly. Some RDECs seem to have no formal approach to information exchange in this area. This is not to say that individual contacts at the bench level of research are not occurring regularly.

Figure 2
IR&D Communication Process[24]



Unfortunately, some laboratories have no mechanisms for informing others about what is being learned. The most effective effort we encountered is at the Communications and Electronics Research, Development, and Engineering Center (CERDEC) at Fort Monmouth, NJ. The IR&D program has been at CERDEC since the early 1990s. The office arranges technical interchange meetings (TIMs) with individual companies via contacts with the companies' local offices. CERDEC's Technology Transfer Office manages IR&D contacts between industry and CERDEC. Sometimes the initiative comes from CERDEC, other times from the companies. They develop meeting agendas, coordinate invitations to interested staff, and manage the actual meetings. CERDEC sends announcements about the meetings to other Government laboratories. On occasion, attendees have come from the Army Research Laboratory, the Armament Research, Development, and Engineering Center at Picatinny, from the Air Force Research Laboratory, and elsewhere.[25] The TIM consists of 3–4 hours of briefings by the industrial firm to a fairly broad audience. While the Army does not brief its own research, it does provide a list of technology needs. The information helps broaden knowledge of the Army staff. These activities are in addition to regular annual Advance Planning Briefing for Industry (APBI) sessions that are conducted to present updates to industry about current programs and needs for new capabilities.

Telephone interviews were held with people at Army laboratories and with contacts in industry to assess the value of the meetings held at CERDEC. The CERDEC Chief Scientist helps industry make in-house contacts. Additionally, he helps the technology transfer office decide whether a meeting should be held across many sectors of the Army, or be narrowed down to one or two directorates within CERDEC.[26] He also urges companies to talk to Army scientists and engineers, often referring companies to program executive officers and program managers at Fort Monmouth. While he spends a fair amount of time on this, he believes that it is well worth the effort.

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[24] Department of the Army, *Army Science and Technology Master Plan for 1997* (Washington, DC: Office of the Deputy Assistant Secretary of the Army for Research and Technology, 2007).
[25] Information from interview with Ms. Michelle Wallner of CERDEC, October 29, 2008.
[26] Information from interview with Dr. Arthur Ballato of CERDEC, October 29, 2008.

Discussions with other Army laboratories were less productive. While someone could usually be found in the technology transfer office who was aware of the IR&D program, that individual typically did not know of any organized activity related to it. One laboratory had designated someone to be responsible for technical interchange, but that individual described the program as inactive. Contacts with acquisition technical and industrial liaison offices (TILOs) were generally not productive. There was little awareness and use of DTIC's database of IR&D reports from industry. Some S&T personnel in the Army who were contacted had never heard of it.

It was difficult in some cases to find an individual at an Army laboratory who was knowledgeable about IR&D. Two of the labs had assigned individuals with nominal responsibility for IR&D, but who had not established an active program for cooperation or information-sharing. Another simply referred questions to an AMC policy document. One or two took the information provided and said that they would look for pertinent information and contacts, but did not follow up.

Further Comments

OSD Commentary

- Mr. Alan Haggerty of OSD is looking at options to reinvigorate the IR&D program. He says that DOD involvement has been allowed to decline dramatically. One option he is considering is to direct the Services to carry out the instructions in a 1999 DOD directive.[27]

- Mr. David Hyman, the man responsible for the DTIC database on IR&D programs, pointed to AFRL and the Army's CERDEC as two places with active programs that might serve as models. He stated that not all contractors supply IR&D information to the DTIC database, and that access to it is limited to DOD employees.

- Mr. Giovanni Pagan, the manager of the AFRL IR&D information exchange program, reports the industry view of the IR&D situation: industry is willing to share information and take feedback from the military, but will not accept military direction of their IR&D programs. The Air Force has begun a formal, three-step information exchange program that has thus far involved about 14 defense contractors.

Industry Comments

Several contacts in industry expressed enthusiasm for technical information exchanges on IR&D with the Army and other DOD components. Some contacts were provided by the leader of the OSD ad hoc group studying IR&D, others came from the Air Force program leader and the CERDEC IR&D officer.

[27] Department of Defense, "Independent Research and Development (IR&D) and Bid and Proposal (B&P) Program," Department of Defense Directive 3204.1, May 10, 1999, available at <http://www.dtic.mil/whs/directives/corres/pdf/320401p.pdf>.

Most individuals contacted in the defense industry, who were mostly from large defense contractors, were positive about the exchanges. Here is a sampling of observations from those contacted:

- One senior official stated that industry wants better communication with the military labs. However, he also complained that the military labs have too much focus on short-term or immediate needs.
- Another official said that much of his company's IR&D work is on the integration of technologies into end systems (this would seem to relate to existing contract work as opposed to longer-range research). He did say that the company does some basic research under IR&D.
- The CEO of a small and highly specialized high-technology lab indicated that he receives IR&D funds from a large defense contractor. This is evidently not uncommon.
- A vice president for technology said that his company participates in technical information exchanges with various military groups and that he is supportive of better information exchanges. The exchanges mentioned were not necessarily identified as IR&D activities. The vice president agrees that his company "could always use more interaction" and "could do better." This company thinks that OSD should take the lead in organizing meetings between a company and military personnel on focused technologies. They do not consider it important whether these meetings are labeled IR&D meetings
- Local representatives at Fort Monmouth of three major contractors commented specifically on their meetings at CERDEC. One commented on the technical interchange meetings (TIMs) arranged by CERDEC. The meetings have "a good atmosphere for collaboration" and a "technical ambiance" and are interactive. The meetings involve personnel from CERDEC and three program executive offices at Fort Monmouth. Another called the CERDEC meetings "very effective–extremely productive." He cited the two-way interaction as being "free-flowing." The companies find out what is relevant to CERDEC's future needs and what is not. A third company found the exchange meetings "extremely useful … and very valuable" and stated that "we love the CERDEC TIM process." He also mentioned in passing the annual APBIs as another means of communicating with DOD.

Conclusions and Recommendations

Conclusions

Some conclusions, based on the preceding discussion of the current IR&D program and attempts to improve it, are as follows:

The contact between military scientists and engineers with industry participants in the IR&D program varies widely. The changes enacted in 1992 have made meaningful management of the program by DOD nearly impossible.

There is currently no requirement that contractors brief their research to military S&T personnel; what information-sharing that is done is voluntary. This is not to say that the independent technical work done by industry under the IR&D umbrella is any better or worse than it was before 1992. Rather, it is to say that Army technologists are less informed about industry research than was previously the case. Most laboratories get their industrial information from informal contacts, usually at the working level.

Some of the current IR&D is shorter-term than intended by Congress.

We learned from one large prime contractor that much of its IR&D work is focused on integration of technologies for finished systems. This leaves less room for longer-term work.

Some DOD components are conducting technical interchange meetings with defense contractors on IR&D related matters.

In these information meetings the contractors present their IR&D work and DOD staff discuss their corresponding work. They also provide lists of their technical needs for the future. AFRL runs a formal, three-step process for information exchange on IR&D. The OSD task force on IR&D cites the AFRL program as one option for the way ahead. The Navy conducts an extensive S&T review with industry that seems to substitute for a formal IR&D exchange.

The CERDEC program is less formal, but seems to provide good opportunities for information exchange. It is highly regarded by industry personnel. The rest of the Army laboratories under AMC are less focused. This leads us to the conclusion that either the Army is not gaining all the benefits from industry IR&D work, or that the Army gains this information from various other contacts apart from IR&D exercises with industry.

Program information is only entered into the DTIC IR&D database by some of the relevant companies. Generally, the information consists of only non-proprietary data.

The current value of the database is in question (see appendix C for more information). We found only a few people who were familiar with the database, and the information they had varied from that given by DTIC. The industry contractors are apparently wary of

entering information into the database. It appears that one cannot obtain a clear picture of what is being done with IR&D funding just by studying the database.

Recommendations

We recommend the following actions to strengthen the DOD and Army IR&D programs:

The Army should establish a more meaningful program of technical information exchanges between the industry IR&D program and the Army S&T program.

The current situation is that such exchanges are fragmentary at best. Regular exchanges would strengthen the Army S&T program and aid industry in planning future research. Ideally, this improved program would be established under the aegis of the Director of Defense Research and Engineering (DDR&E) and encompass all of the Services.

The Army, ideally in concert with DDR&E and the Services, should develop an agreed upon format with industry for information to be provided both from industry to the Army, and from the Army S&T programs to industry.

Data in this format should be sufficient for industry and Army scientists and engineers to agree on topics to be briefed at regular information exchange meetings.

Data provided from the IR&D information program should be standardized and contain brief programmatic descriptions, without too much technical or financial detail.

The data should simply indicate the general technical areas being studied. The data can be provided in a simple paragraph format, or even as a simple listing of project titles. The Army should provide a similar list to industry of priority needs and corresponding research programs.

The information exchange meetings should be modeled on the best elements of the AFRL, Navy, and CERDEC efforts.

In a standard format, these meetings can provide Army S&T staff with knowledge of what industry is studying for the future, as well as describe to industry both the military's needs and the outlines of the Army's current S&T program. The AFRL program on IR&D provides for Air Force needs and industry research. The Navy program provides in-depth discussion of Navy S&T and offers an opportunity for industry to privately discuss its S&T work The CERDEC program primarily provides industry research alone.

Each Service should design its own information exchange meetings, based on the DOD format for the supply of such information, to take into account the differing structures of the Service S&T programs.

The Air Force runs its IR&D information exchanges through its main laboratory, AFRL, which, in turn, brings in the Air Force product centers. The Navy's Office of Naval Research conducts its information exchange with industry, but the exchange is not

explicitly focused on IR&D. Both the Air Force and Navy approaches are more comprehensive than that at CERDEC. CERDEC represents only one component of Army technology. AFRL and ONR represent most of their Services' active technology programs.

Special procedures should be developed to protect the proprietary nature of the information provided by industry.

Industry is not willing to share details of its forward-looking research with other companies and often requires military personnel to sign non-disclosure agreements. While companies can sit together to hear military priorities and program descriptions, companies will have to brief their programs to Army staff separately. This could be achieved either by holding entirely separate meetings with each company, or through having a plenary meeting with all interested companies, followed by separate industry briefings.

These meetings should be rotated so that any one company need only attend one meeting every 3 or so years.

Participation in technical information exchange is, according to law, voluntary. Not all companies will opt to participate. More companies will participate if the information on military priorities and research programs is combined with the IR&D briefings. To make the workload manageable for the participants, these meetings should be spread out over time. Frequency should be negotiated with each interested company.

OSD and the Services should make it abundantly clear that awareness of industry research is a required part of each military scientist's and engineer's position.

Scientists and engineers are expected to know what research is being done in their fields by reading the literature, attending professional meetings, and visiting other laboratories, often on a worldwide scale. However, industry often does not share its research on future technologies because of proprietary concerns. Thus, the meetings described here are an additional avenue for military technical staff to obtain valuable insights for guiding their military research.

The thrust of this study is that while the long-term research and development that industry is doing in defense-related areas is a valuable source of new information for the Army and DOD, the current implementation of the IR&D program is not providing that information very well. By taking a fresh look at how information sharing with industry could be done better, and by developing processes to facilitate such sharing, the Army and the DOD S&T programs would profit greatly.

Appendix A: Persons Interviewed

Office of the Secretary of Defense
Alan Haggerty, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics
Dave Hyman, Defense Technical Information Center, Special Collections, IR&D, and Technology Transfer

Defense Laboratories
Art Ballato, Army Communications and Electronics Research and Development Center (CERDEC)
Michelle Wallner, Plans and Programs, CERDEC
Grace Bochanek, Technical Director, Army Tank and Automotive Research and Development Center (TARDEC)
David Gorsich, National Automotive Center at TARDEC
Ron Hinkle, TILO, Army Edgewood Chemical and Biological Center (ECBC), Edgewood
Giovanni Pagan, Plans and Programs Directorate, Air Force Research Laboratory (AFRL)
Vince Russo, Exec. Dir. (ret.) Aeronautical Systems Center, AFRL
Joe Lawrence, Office of Naval Research
Mike Rausa, Technology Transfer Office, Army Research Laboratory
Mike Rutkowski, Director, National Rotorcraft Technology Center, Aviation and Missile Research Development and Engineering Center (AMRDEC)
Dave Skatrud, Director, Army Research Office

Industry
James Chew, Vice President of S&T, ATK (Alliant Techsystems)
Rich Dinges, Director of Tank Systems with Chris Cardine, General Dynamics Land Systems
Jack Hammond, Vice President of Technology, Lockheed Martin
Bill Jeffrey, CEO, HRL Laboratories
John Kleinfelder, Raytheon, Fort Monmouth Office
John Milewski, Northrop Grumman, Fort Monmouth Office
Ed Stephenson, Boeing, Fort Monmouth Office

Appendix B: IR&D Roles and Responsibilities in DOD

Coordination is to be achieved by the Department of Defense components through the following:

- Information exchange activities.
- Technical Interchange Meetings initiated by either DOD activities or contractors.
- Other voluntary technical discussions or exchanges of information between the scientific, engineering, and operational personnel of the Department of Defense and the contractors.

Management of the program is the responsibility of the Director of Defense Research & Engineering (DDR&E). The DDR&E is to:

- Issue policy and guidance for all DOD activities on the technological aspects of IR&D and bid and proposal.
- Encourage the communication of contractor IR&D activities and results to the Department of Defense.
- Ensure the communication of DOD needs, interests, and priorities to contractors.
- Establish and appoint the Chair of, and oversee the activities of, the TCG [Technical Coordinating Group] that shall (among others):
    - Establish policy and implement and oversee activities necessary to achieve the objectives of DOD IR&D policy.
    - Provide policy authority for providing DOD technical and programmatic information to contractors they need to effectively implement their IR&D program.
    - Provide oversight of the DTIC IR&D database.

The Secretaries of the military departments shall designate a senior S&T manager who shall serve as the representative for the military department on the TCG and who shall coordinate all military department activities for the technological aspects of IR&D.

Appendix C: A Brief Look at the DTIC IR&D Database

This appendix discusses the results of a brief survey of the IR&D database maintained by DTIC. The DTIC database supervisor informed us that the total dollar value of all submitted reports in 2006 was roughly $1.3 billion,[28] or slightly more than half of the $2.377 billion approved by DOD. The present evaluation consisted of a review of about 300 technical reports, consisting of more than a third of the total 2006 submissions. These were assessed for the basic cost of the reported projects; about 40 were reviewed for technical content. The evaluation was limited to submissions from five of the largest defense contractors.

As discussed in the main body of this report, contractors who wished to be compensated for independent research and development prior to 1992 were required to have their programs periodically reviewed by the Government. As part of Public Law 102-190, those reviews were eliminated, along with the annual, centralized negotiation of reimbursement ceilings. The current DTIC database is a voluntary substitute for the earlier, mandatory reviews. The mandatory reviews were meant to ensure that funds provided by DOD were in fact satisfying Government goals of promoting independent defense research. A useful, secondary benefit of the former reviews was compulsory sharing of information within the DOD community and its S&T programs about forward-looking, private, defense-supported R&D.

Principal conclusions from this survey are:

Fiscal information:

- Only about half of IR&D reimbursed dollars are represented in the DTIC database.
- Extrapolation of the reports from four of the largest defense contractors suggests that their reports account for about one-fifth of the IR&D program.
- In 2006, only about 10 corporations submitted reports to the DTIC database. Reporting is dominated by large defense contractors. Among these contractors, cooperation varies widely and may not represent overall DOD reimbursement well.
- Collecting aggregate information about any one contractor is currently an overly difficult task, due in part to "shortcuts" and inconsistencies.
- Most reported projects are reported as having a financial value most commonly associated with basic and applied research (less than one million dollars).

Technical information:

- Of the 40 documents reviewed, just over half of them had insufficient, minimal or no technical detail.
- Of the documents reviewed, about 25 percent contained no technical information. In some of these reports, the projects did not appear to qualify as genuinely

[28] Email from David Hyman, DTIC, February 3, 2009.

advanced research and development although the official guidance does allow a broad range of activities.

Part 1—Fiscal Details

The major components of the DTIC IR&D database are the IR&D reports themselves and the web-based interface responsible for organizing, searching, classifying, and retrieving them (as well as providing related information). The reports themselves begin with a page of summary data and contact information for a corporate representative. This section also contains the cost of the research for the year covered in the report and in the project's prior year. The second section of the reports contains a series of spaces for open-ended descriptions of project aspects by the contractor. The headings provided are "Need," "Objective," "Approach," and "Progress." It is worth noting that only the latter two would be expected to contain technical information on the research.

We selected the 2006 DTIC submissions of five large defense contractors for review. Of the five contractors, one discontinued reports to the database in 2005, and another appeared to have submitted only an unrepresentatively small number of reports (about ten), in comparison to their very substantial R&D budget. The other three contractors submitted a substantial number of reports (more than 50). For the three significant contractor report sets, the total value for each contractor ranged between $35 and $145 million. Lastly, we calculated the average cost per project per year for each contractor, and obtained values ranging from roughly one-third to more than three-quarters of a million dollars per project. Our review has shown that well under 20 percent of the reviewed reports allocated project costs of over $1,000,000 in a given year, and less than two percent allocated costs over $5,000,000.

The total value of the 2006 report sets from all five large contractors is estimated as $266,000,000.[29] DTIC informs us that the total dollar value of all submitted reports in 2006 was about $1.3 billion dollars. Therefore, our work suggests these reports from the five large corporations accounted for about 20 percent of DTIC submissions and about 10 percent of the $2.35 billion dollars of IR&D reimbursements provided by DOD in 2006. (However, one must remember that one large contractor submitted no reports and for another we only looked at some of their reports). Our reported cost figures rely on certain assumptions that were required to compensate for problems with the database.[30]

Part 2—Technical Details

Part 2 of the assessment focused on the quality of the technical information provided by the reports. For part 2, we reviewed 40 reports of the 300 or so used for cost study, ten from each of the four contractors who provided reports in 2006 or 2007. Each of these reports was evaluated as to the depth of technical and methodological detail provided.

[29] The values of four of the sets were calculated directly from all of 2006 reports of these contractors. For the fifth set, an estimated value was extrapolated from the 100-report sample, representing slightly less than a third of the reports. The value of all directly reviewed reports was about $150 million.

[30] For example, we have used 2007 reports on 2006 costs, when they differ from 2006 reports. Also, we have assumed that reported costs of $0 are "placeholder values," following guidance from the DTIC office, and substituted prior-year costs in these cases. These measures, while necessary, allow the possibility of differing estimates.

Other criteria, such as accuracy, relevance, or cost-effectiveness, were beyond the scope of this evaluation.

The review returned the following results:

- Of the 40 documents reviewed, just over half of them were rated as below acceptable (little or no technical detail). These reports provided little or no technical description of the methods used in performing the research or the qualities goals and results. These reports essentially failed at least one of the two stated goals of the database, which is to make private-sector methods and techniques available to public-sector R&D organizations.

- Of the documents reviewed, about 25 percent of them received a vey low score. These reports not only contained no technical information, but in many cases did not appear to qualify as research and development. Some may have related to new capabilities, but the reports themselves appeared to be entirely managerial or bureaucratic in nature. A few appeared to only be business plans.

In conclusion, this survey of the database reveals that it does continue to receive voluntary submissions from some contractors. Some contractors reportedly find the database to be a useful way of publicizing and documenting their research to relevant DOD officials.[31] However, there is clearly much R&D that goes unreported. These findings bolster this paper's conclusion that some way must be found to make at least a full list of topics under study by contractors in the IR&D program available to DOD S&T personnel.

[31] Telephone interview with David Hyman, DTIC, January 9, 2009.